DIVISION OF THE HUMANITIES AND SOCIAL SCIENCES

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA 91125

PATENT POLICY, TECHNOLOGICAL INNOVATION, AND GOVERNMENT CONTRACTS: A SELECTIVE CRITIQUE

Wayne D. Collins, John A. Ferejohn
and Daniel J. Kevles

SOCIAL SCIENCE WORKING PAPER 56

October 1974

In traditional economics, the patent system has rested on a twofold justification: 1) The award of a temporary monopoly to the creator of an invention will induce investment in inventive activity; 2) Given such a temporary monopoly, the inventor will make his invention public knowledge. Numerous writers have treated the first assertion, and a few have considered the second. But there is also a general welfare question to be considered: Is society better off with a patent system than without one?

This basic question ramifies into any assessment of federal patent policy. First, patent policy can affect the rate and direction of technological innovation. Second, it can play a major role in determining the control within the private sector over the process and exploitation of innovations. A few writers have addressed the general welfare question in patents. Moreover, the arguments and analyses advanced by these writers have found expression in the public arena, particularly since World War II, when the federal government entered the area of research and development contracting in a massive fashion.

Clearly, answers to the general welfare question turn on what the actual effects of the patent system are compared to a world in which no such system exists. There are two fairly good literature reviews which summarize the arguments of the neoclassicists on these points.[1] J. B. Clark argued in his Essentials of Economic Theory that without a patent system there would be very little inventive activity. "If an invention became public property the moment that it was made, there would be small profit accruing to anyone from the use of it and smaller ones from making it . . . . The system which gave a man no control over the use of his inventions would result in a rivalry in waiting for others rather than an effort to distance others in originating improvements."[2] Frank Taussig and A. C. Pigou seem to argue that the total of inventive activity is not much increased by the grant of monopoly power but that the allocation of such effort is so affected. Pigou says: "By offering the prospect of reward for certain types of invention they do not, indeed, appreciably stimulate inventive activity, which is for the most part, spontaneous, but they do direct it into channels of general usefulness."[3]

Pigou's statement points to the fact that, whatever effects the patent system may or may not have in increasing the level of inventive activity, it is also likely to bias the mix of what activity is undertaken. The patent law of the United States provides, for example, that inventions may be patented while "discoveries" of scientific laws may not. Also, there is an elaborate and changing corpus of rules and laws which permit certain kinds of inventions to receive patents while others may not. As far as we can tell, there seems to be no particular reason to believe that whatever bias is introduced in the direction of patentable inventions is advantageous or disadvantageous from a general welfare point of view.

Other neoclassical economists, such as A. Marshall, argued that the patent system favors large corporations at the expense of small firms. J. M. Clark argued that firms with monopoly power will use the patent system to secure that power by engaging in patent suppression. Others have argued that while the patent system does induce inventive activity, it induces too much of the wrong sort. By protecting the original inventor, if he is successful in marketing his mousetrap, other firms will have an incentive to "invent around" his patent in an effort to secure a share of the monopoly profits. The original inventor (or the firm that he licenses) will also have an incentive to invent around the patent for defensive purposes. A. Plant argues that the encouragement of innovation by the patent system leads to "too much" technical change of the wrong kind.[4]

Some of these economic arguments found expression in the

political arena during World War II, when it was charged that patent abuses were responsible for acute shortages of such strategic materials as beryllium, magnesium, optical glass, and chemicals. To reconstruct the assumptions and arguments of the critics, various big business corporations possessed patents for ways to create and manufacture substitute materials but had left these patents unexploited. In part, it was because they had entered agreements with foreign, including German, cartels which prohibited them from developing certain types of processes in the United States. In part, it was also because they tended to protect their own economic position, so the argument ran, by blocking other producers, especially technologically innovative small businessmen, from entering the market. They bought up, then suppressed potentially competitive inventions or tied them up in costly patent infringement suits. According to the widely publicized final report of the Temporary National Economic Committee, 1941, big business corporations used the patent system "to control whole industries, to suppress competition, to restrict output, to enhance prices, to suppress inventions, and to discourage inventiveness."[5]

The patent issue was amply dramatized in the rubber crisis of 1942. Once the Japanese conquest of Southeast Asia had cut off the supply of natural rubber, the nation's stockpiles diminished so rapidly that the President called upon the public to turn in old tires, garden hoses, bathing caps, and raincoats. "Why had no synthetic rubber industry been developed in anticipation of the need?" critics asked. A blue-ribbon Presidential committee headed by Bernard Baruch attributed the situation to a complicated mixture of human, bureaucratic and technical failures. Thurman Arnold, the administration's chief trustbuster and a member of the Temporary National Economic Committee, found a quite different answer, which he detailed in a 20,000 word antitrust complaint. The complaint charged the existence of sinister agreements between the German chemical cartel I. G. Farben

and the Standard Oil Company, which held essential synthetic rubber patents and had refused to license them to other U.S. manufacturers. The Justice Department dropped the charges for the duration in the interests of the war effort, but not before Standard agreed in a consent decree to make available its synthetic rubber patents on a royalty-free basis.[6]

If, as several of the older economic theorists believe, the patent system does induce inventive activity, the historical record suggests that it may also retard the introduction of certain innovations. In addition, one may find in both the literature and the historical record considerable controversy over whether or not grants of patent monopoly tend to encourage a trend toward monopolization in the economy. The older economists seem to split on this question as well. Some, such as J. B. Clark, claim that by giving some monopoly power to a new entrant he is able to secure a foothold in a previously monopolized market. Others (Lionel Robbins, Arthur Burns, F. A. Hayek) see the patent system being used to cartelize previously competitive markets through pooling agreements and the like.

During World War II, the enormous increase in federal R&D expenditures threw a spotlight on the relationship between patent policy and industrial concentration. In the late Thirties about two-thirds of all industrial research workers were employed in fewer than ten percent of all industrial laboratories, and the war was doing nothing to change this degree of concentration. To the Army, Navy, and Office of Scientific Research and Development (OSRD), it seemed the wisest course to rely upon the best-staffed and best-equipped technical organizations. Together, by 1944, these three agencies had awarded industrial laboratories research and development contracts amounting to some $900,000,000, which equalled almost half the federal government's total wartime investment for the purpose outside

of atomic energy. Some 66% of these industrial contracts went to only 68 corporations, some 40% to only 10. More than nine out of ten of these contracts followed a policy that granted title and all commercial rights to the contractors.[7] Though the government would receive a royalty-free license for governmental purposes, it seemed that the distribution of wartime R&D contracts would vest considerable postwar commercial control of defense-related patents in a relatively small number of corporations. In any case, a number of critics asked, since the government paid for the wartime R&D , should it not as a matter of equity and as agent of the public own the fruits of the research ?

Whatever the answer to the question of equity, there has been a good deal of argument in the scholarly literature concerning the relationship of patent and antitrust policies. Patent and antitrust laws are generally viewed to be in diametric opposition. Patent laws promote monopoly while antitrust laws promote competition. However, while the mechanisms available under the laws are antithetical, the intent of both sets of laws is the same -- to promote the welfare of society. Ward Bowman argues that within the intent of the laws, no divergence exists.[8] As several surveys in addition to Bowman's examine this complex controversy in considerable detail, we shall not attempt to address the issue here.[9]

What we will attempt to do is this: First, since there is so much disagreement over the welfare effects of a patent system, we will examine some simple but explicit models to see what features of the patent system the early writers may have seized on that lead them to such diverse conclusions. Second, we will draw upon this discussion to suggest how the patent system might be manipulated to improve the welfare output. Third, we will consider one of the main manipulative possibilities to have received attention -- the so-called title versus license policy -- and assess the literature in this area. Fourth and finally, we will draw some conclusions about the general problem,

including certain suggestions about the political realities of patent policy and policy strategies.

I. A SURVEY OF MODELS

The principal allocative features of inventive activity are these: First, the generation of knowledge entails significant external effects. Second, exclusion or appropriability is limited. And third, the inventor confronts both technical and market uncertainty, while institutional arrangements do not permit him fully to shift risk to the degree that he might like. These three features are ably discussed in Arrow's essay and according to him (and others) each of these factors tends to induce underinvestment in inventive activity.[10] As might be expected this conclusion, though widely shared, is by no means uncontested. Indeed, some economists have argued that there is some reason to suspect overinvestment in inventive activity.[11]

The argument that there will otherwise be too little inventive activity is the major economic justification of the patent system. The basic assertion is that by increasing the ability of an inventor to appropriate the rewards of his invention (i. e., by narrowing the gap between the social and private reward from his activity) more invention will take place. Evidently this justification would fail either if the argument of inadequate inventive activity were undermined or if the claim that patents induce invention were shown to be false. We shall therefore concentrate here on casting about doubt as liberally as possible, erring more frequently on the side of skepticism than of faith. We shall deal with the three issues of appropriability, externality, and uncertainty and the effect of the patent system on each.

A. Appropriability

Does a patent system have the effect of increasing the ability of

an inventor to appropriate the rewards of his invention? Both empirical and theoretical work on innovation under rivalry is based on the recognition that, generally, in the absence of patent considerations there is a certain amount of "natural appropriability" in innovations. Once a firm introduces a new product or cost reducing process it enjoys monopoly power for a certain period before it is imitated. Empirical studies by Mansfield of how long it took firms to adopt innovations in the railroad, bituminous coal, iron and steel, and brewing industries indicate that imitation often is quite a slow process. Moreover, the forces affecting imitation seem to vary by industry and by invention.[12] There is evidence in these studies that imitation is such a slow process that introduction of patent rights may have had negligible effects.

Theoretical studies by Kamien and Schwartz[13], Barzel[14], Scherer[15], and others have focused on innovative activity in various kinds of economic environments without a patent system. Each of the models is unique in major respects and consequently they generate somewhat different conclusions. Barzel, using a rather loosely defined concept of rivalry, argues that increased rivalry leads to premature innovation. Scherer's game theoretic models produce more qualified results which depend on several factors. For example, in considering Nash equilibria for a duopoly, Scherer finds that, if the length of time the imitator waits before imitating does not affect the share of the market it can obtain, then the innovator will not change his introduction time in response to changes in schedule by the imitator. Additionally (still assuming Cournot-Nash behavior) Scherer finds that the greater the number of firms the stronger incentive firm i has to conduct its development rapidly, and so forth.[16]

Using another concept of rivalry, Kamien and Schwartz reach quite different conclusions. They find that increased rivalry delays innovation. In their models firms characterize their environment by a probability distribution over rival introduction times. As in the other models there is technical and market certainty. The general result is

that as the probability that a rival innovates first increases, innovations that would have been introduced "soon" by the firm are introduced sooner. On the other hand for those innovations that would have been introduced later, increased probability of rival introduction tends to retard innovative activity by the firm. Finally as the probability of rapid imitation increases, the firm tends to delay innovation.

The introduction of a patent system has the effect of inhibiting or preventing imitation. Consequently the fear of rapid imitation need not enter into the firm's calculation to as great an extent with a patent system as without one. For this reason, some believe that to varying degrees, the patent system increases appropriability for the innovator by partly removing the ability of imitators to sap away quasirents accruing to an innovator.

Before accepting this conclusion, however, several other factors must be taken into consideration. In order to obtain a patent, the fine details of the invention must be publicly disclosed. Possibly competitors will utilize the disclosed information to "invent around" the patent and offer a similar product at a lower investment cost. While it is true that the patent system in part counterbalances the advantage of disclosure to the competitor by increasing the engineering and legal problems for the imitator (and therefore his costs), it is also true that enforcement of patent grant from infringers is not costless to the holder. A similar reciprocity of increased costs exists if the innovator patents near-substitutes defensively.[17] While such action increases the costs greatly to imitators, it is not costless to the innovator and may in fact exceed many times the R&D costs of original invention.

Innovators must take into account that patent longevity is fixed in the present system at 17 years.[18] For most inventions, a patent grant for this length of time is excessive since innovators would be willing to accept a patent of shorter duration for the benefit of nondisclosure. In this case, society could be made better off by shortening the duration of

the grant up to the point where the inventor is just willing to disclose. Of course, there is one problem in constructing an institution to determine this point. After all, the innovator has no incentive to state the shortest duration necessary for him to disclose, and if an outside party must do this determination, the invention must be first disclosed to the party. The result is similar to Catch-22.

We must also recognize that inventions may develop for which the 17 year monopoly grant is not sufficient to induce disclosure. In such cases, it may be socially desirable to extend the length of the grant. Of course, the same problems exist in this situation as in the case where the grant was of too long a duration.

Another factor to be considered before adopting any conclusion on the effects of a patent system on appropriability is the non-economic institutional environment in particular, the attitude of the patent office and the courts. Some authors have suggested that there has been a tendency for standards of patentability to rise through time, for only specific (rather than general) patents to be granted, and for an increasing number of challenged patents to be struck down. We have also assumed the candidate firm to perform the R&D as a rational actor when in fact it is an organization made up of divisions of labor, two of these being management and research. Some authors have argued that the major incentives stemming from appropriability should be directed toward the individuals in the research division rather than management.[19]

The considerations in this section indicate first of all that there are many different kinds of possible patent systems; second, the amount of appropriability guaranteed by any of them varies; and third, because of the possibility of litigation, whatever appropriability is obtained is not without costs. In view of these observations, it is somewhat dubious that whatever actual system of patent right is in force significantly increases the ability of an inventor to capture the rewards of his idea.

B. Externality

Some authors seem to view research and development activity as consisting of the production of inventions which may be put to specific uses in reducing the costs of particular production processes, or (in the case of new products) in satisfying consumer desires; but others take the view that research and development is the production of information.[20]

For these latter authors, an invention allows each person to reformulate his expectations about what the true state of the world is and, to the extent that, his revised beliefs affect his allocative decisions profit from this information. Of course, if the information content of an invention is profitable (in the above sense) to only one person or firm, then there is no externality problem. Indeed, the theoretical and empirical studies which suggest the importance of natural appropriability and, consequently, barriers to diffusion may be recast to argue exactly this point. As it is however, few economists have addressed this particular feature of inventive activity and so the comments we make here are largely ungrounded in the existing literature.[21]

Many economists seem to accept this much: The introduction of patent rights may well increase the allocation of resources to inventive activity; in the absence of such rights, such activity may well suffer from underinvestment. To the extent that the introduction of a patent system discourages these conditions, it is beneficial. However, much in this statement warrants examination. In particular, we may note that some inventions would seem to convey a lot of valuable information to many firms, while other inventions are valuable to only a few. What, then, is the effect of patent rights in the allocation of resources as between these two types of invention?[22] Many analysts have stressed the importance of this question -- and also the fact that it remains largely unanswered.

From the point of view of the production of information, the definition of patentability is a critical determinant of how well any patent system encourages investment in innovation. The patent system in the United States does not permit patenting of basic scientific ideas while, on the other hand, can openers are fair game. To some extent such a system would seem to encourage investment in can openers at the expense of basic science. It has been suggested that one precondition to patentability be "usefulness."[23] Many of the decisions of early court cases seem to be of this persuasion.[24] Nonetheless, in most recent courts, the trend is to favor patents only for specific increments of hard technology.[25] In the presence of such unexamined allocative phenomena it is hard to conclude that patent rights encourage the production of the sort of information that is valuable to many agents in the economy.[26]

Finally, as Arrow argued, the institution of patent rights allows a patent holder to charge a price for the use of information which is in excess of the cost of transmitting the information. Patent rights therefore inhibit the utilization of the existing stock of knowledge as well as altering the allocation of resources to various kinds of research and development.

C. Uncertainty

The literature on the economics of invention focuses on two major kinds of uncertainty which face the inventor. First there is technical uncertainty: The inventor does not know in advance what output he will be able to obtain from a given combination of inputs. Secondly, he faces market uncertainty: If he succeeds in producing (let's say) a new commodity at a particular unit cost, he does not know what the demand for it will be. Obviously there is a certain interdependence between these concepts but the distinction seems intuitive enough and certainly economists interested in resource allocation have tended

to analyze these two kinds of uncertainty separately. In any case, given the presence of these kinds of uncertainty, and the absence of the full range of risk-shifting institutions required for the achievement of efficient equilibria, risk-aversion on the part of inventors and financiers will tend to inhibit inventive effort.

This simple conclusion has provoked objections from some economists. As A. Phillips has pointed out "While there are risks associated with investment in research and innovation, failure on the part of the individual firm to undertake these risks entails the more substantial risk that another will succeed."[27] How significant this third form of uncertainty is as against the former two depends on several factors. First if the invention in question is difficult to duplicate or utilize (i.e., if it has natural appropriability), the original innovator may enjoy a relatively long period of obtaining monopoly rents while those firms which failed to innovate may suffer serious losses in sales revenues and market shares. Secondly market characteristics may be such that the longer it takes firms to copy an innovator, the less able they will be to obtain a given share of the market.[28]

On the other hand Baldwin and Childs have argued that in some circumstances large firms may find that their best strategy with respect to research and development is what they call the "fast second."[29] That is, such firms should not try to engage in creating new inventions but rather specialize in "reverse engineering." When a smaller firm introduces an innovation the large firm obtains valuable information which enables it to reduce both technical and market uncertainty. It can then engage in imitative activity, and once having achieved a successful copy of the original innovation, utilize its superior marketing organization to retain its dominant position in the industry. In the light of this work by Baldwin and Childs it is difficult to conclude comfortably that the risk of someone else's being

first will necessarily induce innovation.

The presence of a patent system is bound to affect the third type of uncertainty, i.e., the risk that another firm will innovate first. After all, it would appear that by inhibiting imitation the patent system would increase the costs to firms of not innovating. To some degree, the fast-second strategy would seem to be made less attractive. However, we do not have sufficient empirical work to be confident of this conclusion, and at least one empirical study, by Comanor, contradicts it. In some industries (and in certain courts) it is very difficult to establish patent infringement, so it is relatively easy for imitators to produce near copies of an invention. Comanor's study of the pharmaceutical industry suggests that even with patent protection, patents are so specific that ". . . it is frequently possible to invent around existing patents; to find a variant which has not been specified, obtain a patent for it, and introduce it as a competing product."[30] Indeed, Comanor presents data which show that, in the aggregate, new products account for the largest proportion of sales in the second year after this introduction. If the patent system discourages the fast-second strategy at all, it would thus seem to do so by lengthening what would otherwise be an extremely short period of natural appropriability to around two years. Comanor also notes that a substantial portion of the research that goes on in the industry is essentially imitative. It seems therefore that the introduction of patent rights raises the costs of imitation but at least in certain industries not so much as to rule out the fast-second strategy.

By allowing the inventor to capture monopoly profits, the patent system would on net increase the allocation of resources to innovative activity and, hence, make less serious the underinvestment resulting from technical and market uncertainty. Or so one might think. But the presence of patent rights means that the firm which

comes in second with an invention gets nothing at all. Thus we can see that a patent system introduces a fourth source of uncertainty into the calculus of invention: In the presence of an inviolable patent the penalty for being second is increased. It is not at all clear that the increased payoff for being first outweighs the smaller one for being second. In fact, we have given conditions elsewhere under which the introduction of a patent system inhibits innovation where the firm is risk-neutral.[31] Evidently stronger conditions could be found if the firm acted in a risk-averse fashion.

However, patents are not necessarily inviolable. As discussed in the section on appropriability, patents may be infringed upon or invented around. This introduces a fifth kind of uncertainty associated with any patented invention: The costs of defending it and the costs of circumventing it. One may imagine situations where, depending on the attitude of the courts, the cost of attacking a patent to have it overthrown is less than the research costs. This would tend to inhibit inventions of greater value than the cost of circumventing them. Again, the effect on this type of uncertainty on innovative behavior all depends on the relative nature of the two costs and the value of the invention.

Finally, we must note the argument that in the presence of uncertainty, we cannot be sure that there is too little inventive activity. Hirshleifer, in a recent paper, suggests that an inventor by virtue of having produced a cotton gin, a new type of automobile engine, or a cheaper process for making steel has valuable information as to what the true state of the world is. He can utilize this information to make bets through (for example) commodities markets. The amount of speculative return he can obtain through his informational advantage would seem to be limited mainly by his ability to borrow money and his caution that extraneous factors may upset his prediction. In the absence of the opportunity to insure against other factors the inventor

may be inhibited in his speculation. In any event, the presence of such opportunities indicates that we cannot be sure that the inventor will be undercompensated in the absence of patent protection.[32] Since, as Hirschleifer says, there is no necessary relation between the technical importance of an innovation and the amount of speculative gain an inventor can obtain, there may be a tendency for too much invention to take place as inventors seek the basis for speculative profits. Hirschleifer remarks that "even though practical considerations limit the effective scale and consequent impact of speculation and/or resale, the gains thus achievable eliminate any a priori anticipation of underinvestment in the generation of new technological knowledge."[33]

In all, it seems that the literature on the patent system gives us little reason to believe that on balance the introduction of patent rights will increase the level of inventive activity in the economy. Although we might be sure that inventors are more able to appropriate the rewards for their inventions than they would be without such a system, this effect may be offset by other changes. For example, if the effect of increased appropriability is to increase innovative activity by a firm, then it seems likely that its rivals will increase their activity as well. But at least some of the literature we have on rivalry suggests that increased rivalry inhibits innovation. Additionally, we have seen that patent rights introduce an additional source of risk into research and development decision-making.

Secondly, even if we were sure that patents stimulate invention, such stimulation may introduce a serious bias into inventive activity. Inventive activity is shifted under patent rights from what it would have been without them. We simply need more information before any conclusions can be drawn on such effects.

Thirdly, there is still some question as to whether we are entitled to conclude that in the absence of a patent system there will be too little investment in innovation. Hirschleifer's novel argument should

cause us to look more closely into the basis of such assertions. One suspects that no simple conclusion of this sort will in the end merit support. Variation by industry, type of innovation, differential access of firms and individuals to capital markets, and other phenomena seem likely to affect the outcome of such an investigation.

Fourth, while we have used the phrase "patent system" repeatedly in this essay, this system is no single unchanging "thing." Within the United States it has varied over time, by industry, and by court of appeals. The presence of such variation should encourage scholars to compare the impact of one sort of patent system with that of another. Indeed economists who have examined the question of optimal patent life have made some strides in this direction.

Fifth, while generations of economists have indicated that the allocation of resources to inventive activity is unlikely to satisfy Pareto efficiency and while some of the same scholars have indicated that a patent system is also unlikely to be efficient, we do not find that much effort has been spent in the search for second best institutional structures. Perhaps it is because the models so far developed in this area are not yet well developed, or because there is general disagreement over what constitute the phenomena of most interest. Still it is discouraging that the state of the art in this area is unable to support any hard recommendations for institutional change.

II. MANIPULATIONS OF THE PATENT SYSTEM

Given the existence of a patent system, and given the lack of second-best institutional alternatives, public policy analysis is left with only one option: To inquire into possible ways to manipulate the patent system so as to increase social welfare. Article I. section 8, of the Constitution provides Congress with the power "to promote the progress of science and useful arts, by securing for limited times to

authors and inventors the exclusive right to their respective writing and discoveries"; it is this clause which permits Congress to make provisions for patents. The clause does not, however, specify the exact nature of the patent. As we have seen, the specific nature of the grant may have a great deal of an effect on the direction and rate of inventive activity.

We wish here to delineate several variations over which a patent grant may be constructed within the constitutional mandate. For our purposes, we need not distinguish congressional changes in statute from executive changes in administrative law. Moreover, for policy considerations we regard it as necessary to consider the patent system both as an institution in itself and as an institution in an environment of other institutions (e.g. antitrust system).

A. General Considerations

Generally, we must consider four aspects of a patent grant: 1) the specific property rights of the grant, 2) the nature of invention required for a grant to be awarded, 3) procurement of the grant and, 4) the enforcement of the grant. The property rights of the patent grant may be further broken down into exclusivity rights and transferability rights. The exclusivity rights of the patent grant operate in three dimensions: inventions, persons, and time. The exclusivity rights place restrictions on the employment (manufacture, sale, and use) of certain inventions by certain persons during a specified time. In the present system, all but few persons without license from the holder of a patent grant are restricted from employing inventions which are "similar" to the patented invention for 17 years after the assignment of the rights.[34] In some other system, patents could be offered which did not restrict employment of the invention without license by nonprofit organizations or firms engaged in health research. Exclusivity rights could also be limited to geographical region. One of the more common suggestions for change of the

present system is the length of patent duration. Perhaps inventions could be assessed for value and patent duration be an increasing function of value (but see p. 9 for difficulties in implimenting the assessment). Transferability restrictions may be placed on the grant. Such restrictions could serve to lower the value of the grant and so in some way redirect inventive activity or wealth distribution.

The nature of invention required for a patent to be awarded hinges on the definition of patentability and the existence of previously awarded exclusivity rights. As noted earlier in this paper, to the extent that the property rights associated with the patent grant are valuable, the requirement for patentability is a factor in determining the direction of inventive activity. To allow patents for can openers but not computer software packages may bias innovation in favor of new can openers. The restriction of previously awarded exclusivity rights may have a similar effect on the rate of inventive behavior by inhibition or encouraging the quality of work in attempts to invent around existing patented inventions.

The procurement requirement of a patent grant may have separable effects on wealth distribution. The grants, for example, could be "sold" by the government to help defray the costs of operating the patent system, increasing the federal R&D budget, or simply as an unrestricted addition to general revenues. The "price" could be a fixed fee at the time of issuance of the grant, the highest bid at an open auction or a percentage on the monopoly rents through the life of the patent. Again, the "price" could be adjusted depending on the status of the applicant (individual, university, for-profit firm, etc.). Another requirement for procurement could be that the invention be commercialized with a certain period of time after the grant or the grant would be sugject to revocation. This might effect, for example, the extent of defensive patenting.

Provisions for enforecment of the grant may be shouldered by the government, left entirely to the holder of the grant, or some combination.

Infringers on the exclusivity rights much be both located and prosecuted. Again, effects on inventive activity and wealth distribution are suggestive. If all costs of enforcement were to be carried by the grant holders, enforcement by small inventors would probably be difficult. Depending on the costs of transferability of the grant (along with the associated problem of negotiating a sale price without actually disclosing the invention), such an enforcement mechanism might eliminate small inventors.

A patent system could be constructed by combining these provisions in various fashions. One patent system might have many different kinds of patent types. Tradeoffs could be made among the four aspects; the combinations are virtually endless. One could even conceive of a system in which each patent application is individually negotiated to determine the nature of the grant. Of course, we must be cognizant of the costs associated with each patent system. All systems require the transfer of some information. Recall especially the difficulties associated with the disclosure of an invention without property rights in order to valuate it. The welfare benefits to be gained by allowing a flexible institution may after some degree be lost or even swamped because of losses associated with institutionally induced information fraud or strategy uncertainties.

In constructing a patent system, consideration should also be given to other legal institutions with incident jurisdictions. Such consideration might include patent recognition agreements in international policy, compulsory disclosure of certain inventions or licensing of patents for purposes of national security (for example, in the nuclear energy field) or the regulation of other industries (e.g., health, environment), special tax status on patent holdings, the legal standing of trade secrets, and limitations of soveriegn immunity from patent infringement actions. While all of these areas are discussed in the literature, two others receiving considerable attention are antitrust and federal contractor policies.

While the intent of both patent and antitrust policies may be to further the public interest, the tools available to each system are inherently at odds. The effect of the patent system is to create monopolies while the effect of the antitrust system is reduce anticompetitive behavior. The basic considerations made in this area will be on the acquisition of patent rights. Limitations may be imposed on the legality of employer-employee contracts which assign the inventions of employees, and the general acquisition of patent rights from a third party for the purposes of monopolizing a process or technique or regimenting an industry. Limitations may also be imposed on the legality of special licensing such as package licensing and tie-ins (licenses will be granted only if the licensee accepts and pays royalties for a "package" of licenses); grant-back licensing (require licensees to "grant-back" rights to the licensor any improvements developed and patented by the licensee); patent pooling, territorial restrictions, quota restrictions in production, or price fixing. Conversely, instead of limitations on the legality of these acquisitions or license restrictions, special sanction exempting them from antitrust proceedings could be incorporated into the patent system. One might argue, for example, that grant-back licensing or patent pooling does not have a substantial effort on inhibiting inventive behavior on the part of the licensee and does allow freer competition.

B. Patents and Federal R&D Contracts

Still another opportunity for manipulating the patent system occurs in the disposition of patent rights for inventions deriving from federally sponsored research and development. Before World War II the government followed a nonuniform policy for vesting such rights. TVA and the Departments of Agriculture and the Interior pursued a "title" policy, meaning that they claimed title to all patents emerging

from research which they financed. In contrast, the Army and Navy followed a "license" policy, meaning that they generally allowed their industrial contractors to retain title to such patents, subject to the provision that the government would receive a royalty-free license to use them for any governmental purpose. Prior to the war these divergent practices within the government seem to have provoked little if any controversy, but during the war and, indeed, since 1945, the issue of title versus license has absorbed a good deal of political energy. It has also occupied considerable space in the literature, perhaps more than any subject other than patents and antitrust policy.

Both the political and scholarly attention seem to have been merited. Federal contracts have become the main source of investment in R&D since 1945, and the patent policy stipulated in them can exercise wide-ranging effects over the direction and nature of inventive activity in the United States and over the extent of concentration and competition in industry. In short, the patent policy stipulated in future contracts can determine to a considerable extent precisely the welfare output of the patent system that is of interest to us.

During World War II, the political hand in this area was taken by Senator Harley M. Kilgore of West Virginia. A freshman Senator and a Democrat with a strong populist streak, Kilgore was an outspoken member of the Truman Committee who became increasingly convinced that a good deal was wrong with the technical side of war mobilization. By 1943 Kilgore had introduced the Science Mobilization Act. Though much of the bill was addressed to the funding and administration of R&D, it included clauses designed to prevent the patent system from working against the public interest, especially by fostering industrial concentration. Kilgore's bill proposed to stimulate technological innovation, the commercialization of new products and

processes, and the entry of small businessmen into markets in part by compelling the disclosure and nondiscriminatory dissemination of information about important technical processes developed in any, including the major, corporate laboratories. To safeguard the public interest against industrial concentration, a new federal agency was to be granted ownership and be enpowered with the exclusive right to use or license "any invention, discovery, patent, or patent right" which had resulted from research supported with "any money, credit, physical facilities, or personnel" by the federal government since the declaration of national emergency in 1941.[35]

Kilgore's bills, especially his patent provisions, provoked considerable opposition, from trade associations, industrial research managers, some leading scientists, and the Army and Navy. The critics dissented from giving the government the power to commandeer scientific and technical data, a power which, in the claim of a scientist at General Electric, would essentially force big business to aid small business by the disclosure of proprietary technical secrets. Worse, according to the way the bill's patent clauses defined federal aid, an industrial corporation would lose all patent rights in an invention if, while working on a government research project, it merely received technical advice from an armed service officer. Unless industry got at least a fair quid pro quo for its contribution to governmentally sponsored developments, Kilgore's opponents were sure, there would be no incentive for industry to participate in federal research programs.

To his opposition, Kilgore's patent policy seemed wrongheaded even in his own terms. Kilgore might want to help small business. If small business firms could not count on monopoly rights over innovations which they produced under government contract, they would be unlikely to risk the investment required for R&D in the first place. Kilgore might want to encourage technological innovation. Unless firms were guaranteed the commercial rights in patents deriving

from federally sponsored research, they would have no incentive to participate in the contract. Kilgore might propose to stimulate the commercialization of patents. Without the protection of the exclusive use of the patent, there would be no incentive to develop an invention into a marketable product. [36]

By the end of the war, the lines had been drawn firmly between advocates of title policy on the one hand and of license policy on the other. All parties in the issue -- in the bureaucracy, industry, and the scientific community -- realized that the stakes were high. Federal expenditures for R&D promised to remain at unprecedented heights in peacetime; in 1946 the federal government was spending some $800,000,000 for the purpose. Considering the stakes, the principals also realized that the end of the war would mark a turning point in this special area of patent policy, and the direction in which the turn was made would seriously affect the nation's economic future. Not surprisingly, each side marshalled its political weapons, including two major summary documents.

For the license policy advocates, the document was the collected reports of the National Patent Planning Commission. Created by President Franklin D. Roosevelt at the end of 1941, largely to investigate the type of abuses spotlighted by the Temporary National Economic Committee, the Commission was chaired by Charles F. Kettering, the inventor of the self-starter and high-ranking executive in General Motors. According to the Commission, it was the judgment of the War and Navy Departments that the patent system had not interfered with the war effort. Acknowledging that abuses did exist, the Commission proposed that all agreements with foreign parties should be published. So should domestic agreements that contained restrictions as to markets, prices, and production. But, declining to call in the corrective power of the federal government, the Commission opposed compulsory licensing, arguing that it would injure small businesses who would have

to license their patents to their large competitors. [37]

Turning to the specific question of patents deriving from federally sponsored R&D, the Commission assumed that the government should not use the patent for purposes of revenue control. Accordingly, the Commission recommended that the government should not ordinarily assert full ownership of patents, except where the public health or safety required it. If the government did come to own a patent, the Commission argued, it should make the patent available only on an exclusive basis to firms prepared to commercialize the invention. As the Commission pointed out, "It often happens . . . , particularly in new fields, that what is available for exploitation by everyone is undertaken by no one." [38]

Quite in contrast to the Commission's report was the document of the title policy advocates, the massive, authoritative report of the U. S. Attorney General on government patent policies and practices. [39] Completed in 1946, three years after President Roosevelt had requested it, this three-volume study was addressed specifically to the question of a uniform policy for patents developed by government employees or contractors. The report strongly urged the establishment of a uniform policy, to be enforced by a Government Patents Administrator. The cardinal point of this uniform policy was that all rights to inventions produced in the performance of a government contract should be vested in the government.

The report proposed that this right might be waived in two cases: first, if the contractor had already made a substantial contribution to the state of the art; second, if the contractor's refusal to enter into an agreement created an emergency which could be alleviated by permitting him greater rights. However, the waiver would have to be approved by the Government Patents Administrator. Moreover, no exceptions to the uniform patent policy were to be allowed unless a reasonable effort had

been made to obtain acceptance by a qualified organization of a title policy contract. In any event, the government was to reserve a nonexclusive, royalty-free license to itself. And the contractor was to agree to place such inventions in adequate commercial use or to license applicants thereunder on reasonable terms.

In a confidential covering memorandum, Attorney General Tom Clark emphasized how "unfortunate" it was that the lack of a uniform policy during the war had probably cost the public a number of patents which should rightfully belong to it. The same mistake should not be made during peacetime. The President, Clark continued, could put the recommendations of the report into effect forthwith by executive order. But though Clark personally favored a title policy, he knew that the armed services as well as the major defense contractors would object vigorously; so would some of the Congress. All things considered, Clark advised the President merely to publish the report and wait for a more favorable moment to make its recommendations public policy.[40]

The War and Navy Departments did object -- and vigorously, to say the least -- to the title policy proposed in the report. Acting Secretary of War Kenneth C. Royall argued that adoption would "wreck" the War Department's research and development programs, which had been difficult enough, he said, to place since V-J Day. Industrial concerns were exhibiting extreme reluctance to enter into R&D contracts. under current policies. (Royall did not specify the source of the reluctance. However, it probably came from the government's insistence upon a royalty-free license on such patents for <u>any</u> governmental purpose, in the face of the demands of defense contractors that such licenses be issued only for the purposes of defense.) Both the War and Navy Departments objected to the central administration of a uniform patent policy. Both the War and Navy Departments together also accounted for 95% of all patent applications handled by government

agencies and supplied over 95% of the federal funds spent for R&D contracts. It seemed highly anomalous to place the rest of the government's departments on an equal footing with them.[41]

To Secretary of the Navy James Forrestal, the adoption of a uniform title policy would impose a "dangerous rigidity which would certainly impede and might altogether imperil the prosecution of a vigorous and effective research and development program." Forrestal emphasized that the vesting of rights ought to vary with the circumstances of the individual contract. As he specified the issues, the terms which the government could obtain in a particular contract would depend upon "the presence or absence of competition, the intensity of any given contractor's desire to obtain the contract, the character of research and development work involved, the price paid for such work, the likelihood of profitable commercial applications, the extent of the particular contractor's investment in prior research and development work in the field, [and] whether the contractor is a non-profit institution of a commercial concern, . . ."[42]

In contrast to Forrestal and Royall. the Secretaries of Commerce and Interior as well as the head of the Federal Security Agency urged the President to establish a title policy. The government ought to assert a title policy at least as a matter of right, Secretary of the Interior Julius A. Krug argued, and, if necessary, permit the various agencies to exercise a certain amount of discretion in the administration of the policy with the consent of the General Patents Administrator. Kilgore, whose title policy had passed the Senate as part of a bill to create a National Science Foundation, had wired the President to adopt a title policy by executive order. But with OSRD as well as the War and Navy Departments objecting so vigorously, even J. Donald Kingsley, a member of the Bureau of the Budget who favored a title policy -- it would constitute "a far stronger weapon against monopoly and industrial concentration that we now have"--

advised that the administration should publish the report for now and await a more favorable time to put its recommendations into practice.[43] Following the counsel of his Attorney General and his White House staff, President Truman did just that, and the report was published in 1947.

But the more favorable moment for the establishment of a uniform title policy failed to arrive during both the Truman and the Eisenhower administrations. As a result, the vesting of rights in patents derived from federally sponsored R&D was left up to the determinations of the Congress and the issuance of regulations on an agency basis. The choices were clear: title policy, license policy, or some combination of the two. All three choices cropped up in postwar government policy -- and all three choices may be found in the extensive literature on the subject.

III. ANALYSIS OF EXISTING LITERATURE

Virtually the entire literature, no matter what the professional discipline of the author, assesses the merits of strict title or license policy in terms of six issues. One issue is the "rights" of the public and of industry, the others center on the policy-specific effects of the cost to the government of sponsored research, the rate of technological innovation, the dissemination of technological knowledge, the potential for invention commercialization, and the economic concentration in industry. Legal analysts tend to discuss these six issues with a methodology which we shall call "legal theoretic." Economists tend to explore them with what we shall call an "economic theoretic" approach. In addition, there appears in the literature, particularly in congressional hearings, a third methodology which we will call "evidential."

Legal theoretic arguments appear in law journals, the patent

trade journal, and congressional hearings. This type of argument generally supports an ethical position on the "rights" of the public or of industry, or it attempts to explore the logical implications of postulated economic "facts." In terms of fully understanding any federal patent policy, two problems are inherently associated with the strictly legal theoretic approach. The first problem is that analysis tends to be based on unexamined premises about how the world should or does work -- for example, competition does (or does not) favor technological innovation. In some cases, these premises are recognized in their general area of study as quite controversial. Many authors fail to note the controversies surrounding one or more of the premises utilized in their legal analysis. The unsuspecting reader may unwittingly assume that the premises are generally accepted as true. The second premise is more subtle. In order to derive useful conclusions from their fundamental premises, it is frequently necessary for legal theoreticians to add structure to the unstated model. For example, assume the fundamental premise that firms profit-maximize. Because of various interactive effects, in particular the elasticities of the supply curve for sponsored research and the demand curve for commercialized derivative invention, it is not clear what will be the relative effects of a title over a license policy. However, it may be possible to generate some suggestive results if we make additional assumptions about these elasticities. The problem arises in legal analysis that the additional structure is often not explicitly stated, poorly justified or simply inconsistent with other assumptions.

Economic theoretic arguments appear in the economic journals in addition to the legal theoretic literature. Economic analysis concerns itself only marginally with the "rights" of the public and of industry and concentrates on policy-specific effects of an economic nature. These analyses appear to suffer from a general lack of substantive agreement. It is probable that this deficiency stems from the absence of a well-structured general economic theory of patents, as discussed earlier in this paper.

Evidential analysis also has no underlying theoretical structure. The arguments rest on empirical observations on the operation of firms under various patent policies or on statements of firm management of how they would operate if patent policy were changed. The problems in evidential analysis are quite clear. Without a theoretical structure, operation under a patent policy cannot be related to firm structure and industry characteristics. It follows that information from evidential analysis cannot be used for predicting changes in firm operation under changes of patent policy. Management officials have no incentive to reveal honestly, even if they know, how they would operate if patent policy changed. In the literature, however these problems tend to be ignored, particularly when evidential analysis is used to support legal theoretic or economic theoretic conclusions.

Issue 1: Consumer and Product

Who is the consumer and what does he buy in a federally sponsored R&D contract? This is almost exclusively a legal theoretic problem. With regard to the distribution of patent rights to inventions incidentally developed while under such a contract, the question is important for two reasons. First, identification of the consumer is necessary to establish who is contending with the contractor for the award of the patent grant. Second, the product of the contract must be examined to determine if any of the parties involved has already relinquished his claim to the patent rights in the provisions of the contract.

In federally sponsored research, the federal government itself or some agency thereof is generally regarded as one (usually the only) consumer of the research. In particular, the federal government is a potential contender for the patent rights to inventions developed under the contract. However, for the federal government to be an actual contender for the patent grant, it must first be established that the government may indeed retain title to such a grant.

At least one author has argued that the retention of a patent grant by the federal government is unconstitutional.[44] Nonetheless, it appears unlikely that further debate on the distribution of patents to inventions under federally sponsored research will become mute because of any resolution of the courts that the government may not hold a patent grant. Still, we must answer the question of what the government may do with the title to any invention. Recall that government action with the patent grant must be consistent with the constitutionally required incentives of the patent system.

Shelton argues that the only allowable government action which meets these consistency requirements is to grant exclusive licenses to private firms.[45] The government is not in competition in the manufacture, use, or sale of products so the right of exclusion granted by the patent is of no use to the government per se. Even so, retention by the government of the principal rights to an invention may be a valuable tool in furthering the public interest. The exclusive license need not be irrevocable. The government could require some form of further development or commercialization of the invention within a fixed period of time or revoke the license. The government has not to date requested royalties for the use of government patents. It has been suggested that an additional application in the public interest of government owned patents would be a requirement of reasonable royalties on licenses and use of these fees to help (as in the British system) defray the expenses of the general patent system operation.[46] Within the literature of the American patent system, we cannot find analyses of the effects the requirement of royalties would have on the demand of licenses (exclusive or nonexclusive) to government owned patents by private industry. Even if it were to be shown that a modification of the present grant of nonexclusive nonroyalty licenses to royalty-bearing exclusive or nonexclusive licenses better achieved the constitutional objective of the patent system, clearly not all royalty schemes would do so.

The lack of a purely competitive market for such licenses would make selection of an optimal royalty scheme difficult if not impossible.

The report of the Attorney General also presents another difficulty with the grants of royalty bearing and/or exclusive licenses.[47] Under these grants, it would be necessary to police the patent rights and bring suits against the infringers. Infringement of government owned patents' rights are not presently prosecuted. Under exclusive licenses, it may be possible to have the licensee, rather than the federal government, prosecute infringers. But this does not alleviate the need of enforcement of the patent rights on which exclusive licenses have not yet been applied for or granted. Under nonexclusive licenses, prosecution of infringers by licensees may be hindered by a free rider problem. In either case, the value of the rights must diminish for the federal government, licensee, or both.

The question of product identity is of obvious importance. In some contracts, we may find that one of the parties has explicitly relinquished claim to the principal rights to incidental inventions developed under a federally sponsored R&D contract. Other R&D contracts, such as those of HEW and AEC, contain provisions which award the rights to the government. Few, if any, government R&D contracts make no provisions for the disposition of rights. Debate on federal patent policy does not, however, revolve around what the patent provisions of contracts are, but rather what they should be. Much of the argument is generated by a lack of agreement among the title policy and license policy advocates on product identity. Title policy advocates see incidental inventions to a sponsored research contract as a product of the contract. The rights of the invention should therefore be the property of the government. If the contractor is allowed to retain the rights, the government is essentially giving away an element of the public domain for monopolistic price exploitation

of the public. The people not only pay the government to have the research on the product performed, but also pay the monopoly price extracted by the contractor.[48] License policy advocates view inventions not explicitly called for in the provisions of the contract and essentially developed as by by-products of the particular approach used to produce the product explicitly identified as incidental to the contract. Rights to these inventions should be given to the contractor. However, most license policy advocates agree that the government is entitled to a nontransferrable, irrevocable, royalty-free license. It is this license, not the title, that the public pays for in reality.[49]

License policy advocates further argue that no invention developed by a contractor is solely the result of an R&D contract. The company utilizes its own facilities, personnel, and know-how in addition to any contracted funds. Contractors are therefore entitled to at least an exclusive, irrevocable license from the government to exploit the patent for commercial purposes. With the exception of being able to issue licenses, an exclusive, irrevocable license from the government to exploit the patent for commercial purposes. With the exception of the power to issue licenses, an exclusive irrevocable license is identical to a license policy (provided, of course, that the government refrains from instituting a royalty requirement).

The discussion so far has concerned itself only with a ceteris paribus analysis of the disposition of patent rights to inventions developed under federally sponsored R&D. The two schools of federal patent policy realize that changes in policy cause redistributions of wealth as those discussed above but also precipitate other effects, such as shifts in demand and supply for sponsored research, in the rates of technological innovation and the dissemination of technological knowledge, in the commercialization incentive, and in the economic concentration in industry. In the next five issues, we will examine arguments that appear in the literature on each of these effects. It

is important to note that each issue, as within the literature, is examined in a partial analysis. Interactive effects between issues are not explicitly addressed. This does not appear in practice as a major concern. Note that the burden of proof has generally fallen on the license policy advocates. Their strategy generally seems to be to demonstrate the adverse effects on each issue of a title policy. Title policy advocates tend only to counter license policy arguments. By the structure of the debate, interactive effects between issues tend to get lost.

Issue 2: Sponsored Research - Supply and Demand

Of necessary concern to both schools of thought are prices, in particular the price of the R&D contract and the price to the public for commercialized incidental inventions. In Issue 1 we have already addressed the question of the commercial price of an incidental invention. Both schools concur that the contractor under a license policy is able to extract a higher price for a commercialized invention.

Patent policy may not only affect the price of commercialized inventions to the public. We may assume that patent policy also enters into the bid functions of all the potential contractors for the R&D. A shift in the patent policy may therefore be expected to cause a shift in the supply curve. Advocates for license policy place the greatest emphasis on this point. The primary assertion here is that companies bid at a significantly higher price to perform a given contract if the patent provisions do not allow them to capture the benefits of incidental inventions.[50] This difference in contract price must be assumed by the public. If the government is not willing to pay the higher price, the contract will not be let. Or assume that Company A would offer the lowest bid price for a given contract under a license policy. Also assume that only Company A has a high probability of developing and commercializing an incidental invention under this contract. It is conceivable that if the contract was now offered under a title policy, Company A would not receive it. This may be due to (1)

the subjective expectation of the winning bid price (based on A's expectation of the conduct of all other bidders) is now too low for Company A to invest in a proposal and submit a bid, or (2) Company A's bid is simply not the lowest.[51] Whatever invention Company A might have developed is now lost to society. License policy advocates maintain that all things considered it is consistent with the public interest to pay the higher product price under a license policy.

The success of this argument hinges on the demonstration of significant adverse price effect on contract bids of title policy relative to license policy. Title advocates maintain that empirically it is not the case that vesting principal rights in the contractor increases competition for government contracts.[52] They implicitly extend this point to infer that if there is no increase in competition, it is unlikely that bid price depends significantly upon contractual patent provisions. While the conclusion may be correct, the extension is quite likely wrong. From a reading of congressional hearings, competition in the above sense seems to refer to number of bidders rather than a level of bid price. In high barrier industries (such as aerospace) one would not expect to observe a change in bidders, even when patent policy is a significant argument of the bid price, if all the companies in that industry depended on government contracts for a substantial portion of their survival. The effect we would observe in this case is a jump in bid price for the contract.

A better argument that bid price does not significantly depend on patent policy is that the offer to vest patent rights in the contractor to unforeseen incidental inventions is of only small positive value to the contractor. Many companies use federal R&D funds not to generate profit but to maintain large diverse scientific and engineering staffs they could not otherwise afford.[53] The know-how developed in federally sponsored research and development may then be transferred to other profit-making operations of the firm. It has also been argued that the most important value

of a federal contract to research and develop a product lies in the inherent advantage of the R&D contractor is becoming the supply contractor.[54] The contractor may trade off profits at the R&D stage (say in order to capture the contract) for expected profits at the supply stage.

Other title policy advocates attempt to counter the charge that title policy adversely affects the research supply curve by an argument based on the traditional motivation of the patent system. The cost-plus-fixed-fee research contract eliminates the needs of a monopoly grant to compensate for risks in R&D. Companies will take this into account when preparing their bid. Therefore, a patent incentive is not needed and in fact is harmful.[55] Whereas the first two counterarguments are solely on evidential grounds, this last is economic theoretic. It implicitly assumes that the only value of a patent to a firm is to compensate R&D risks. Many theoretical agruments (both economic and legal) reject this point by placing a value on the defensive property of patents. Clearly, a strictly legal theoretic analysis of this issue would hinge on the acceptance or rejection of a defensive theory of patents. The failure of many legal theoretic analyses to recognize this consideration is illustrative of the lack of properly integrated legal and economic theory.

Issue 3: Technological Innovation under Sponsored Research

License policy advocates assert that title policy adversely affects the rate of technological innovation. Under a title policy, there is no extra payment to contractors for developing derivative inventions. Moreover, rewards to the contractor bear no relation to the quality of what he invents and, by definition, all rewards inherent in the ownership of the title accrue to the government. In short, if the government demands more than a royalty-free, nonexclusive license, no incentive exists for a contractor to generate any work not related to the delivery of the product specified in the contract.

Some license policy advocates go so far as to say that poorer quality technicians would be assigned to those projects operating under a title policy, lessening the chance of a breakthrough and of developing incidental inventions.[56] It is the temporary competitive advantage of a patent monopoly which encourages a firm to take the financial risk of investing its money and talents in R&D. All other things being equal, the firm would utilize its risk capital and best talents on license policy contracts over title policy contracts. The effect may extend to those firms which also have profit-making projects in the private sector.

Title policy advocates respond on several different levels. On the legal theoretic side, private employers and government contractors traditionally demand and obtain as a condition of employment the complete assignment of rights to inventions made by employees under firm sponsorship. By analogy, since a government contractor is an "employee" of the government, the government should be able to exercise similar options. Other advocates maintain that the issue is irrelevant, since the government does not select contractors on the basis of their ability to create derivative inventions but rather on the bid to deliver specified products. On the economic theoretic side, some title policy advocates argue that the incentives of scientists and engineers to invent are independent of the contractual provision agreed to by management. Federal patent policy would have no effect since the inventors themselves do not receive principal rights under either policy. Others have even suggested that under certain circumstances, individual inventors working for private contractors on federally sponsored R&D projects would have an increased incentive to invent. Recall that when the government acquires the principal rights to an invention, royalty-free licenses are generally available upon request. It would be possible for the individual inventor to leave the contracting firm and further develop, produce, and market the invention on his own license. Additionally,

the market value of the inventor may improve since other firms may obtain a license to his invention, and the inventor may be hired for his "know-how" without fear of a subsequent infringement suit.[57]

Issue 4: Dissemination of Technological Knowledge

The fourth issue of the controversy is the dissemination of technological knowledge produced under contracted research. Title policy is asserted to assist dissemination of knowledge, since government ownership of patents eliminates barriers of industrial secrecy.[58] Additionally, the government needs the principal rights to inventions to insure that the inventions are actually disclosed. Under license or irrevocable licenses granted by the government the indifferent contractor who does not apply for a patent loses for technology the information he has developed and loses for the government a license by which it may partially control the knowledge.[59]

License policy advocates counter by asserting that the government does not require title to facilitate widespread access to the new technological knowledge. When a contractor files for a patent, full disclosure of the new invention is obtained and the government is free to disseminate the new knowledge as it chooses. Title in the government would give only the additional right to license firms to produce a product from the knowledge (which is a point fundamentally different from that made by the title policy advocates on the issue). License policy advocates question the fundamental assumption that the government would actively attempt to facilitate dissemination if it had the principal rights in the first place.[60]

In the case of the indifferent contractor, no additional incentives exist in a title policy over a license policy to disclose patentable knowledge. Some license policy advocates maintain that unless new incentives are created, neither license nor title policy will affect disclosure of this type of invention. In the first 27 months of NASA's operation under a full disclosure rule regarding technological information, only 81 invention disclosures were reported

in over one thousand research contracts.[61] Others argue that it is title policy that adversely affects disclosure. Firms may conceal the development of incidental inventions when under a title policy to prevent them from becoming elements of the public domain.[62] One author goes so far as to say that the requirement of a royalty-free irrevocable license to the government granted under a license policy made bad to fraudulent representations that incidental inventions have not been discovered while on a federal R&D contract.[63] Some firms may decide that unless they can receive all rights to incidental inventions, it is in their interest to keep (fraudulently) such inventions as trade secrets.

Issue 5: Commercialization of Inventions Developed Under Sponsored Research

On this issue, license policy advocates basically follow two lines of argument. First, government ownership of principal rights defeats the normal incentive for industry to commercialize patented inventions. A new invention will be commercialized only when firms are able to ban competition in order to receive initial investments. Since a title policy would make available nonexclusive licenses, the competition could not be banned and so minimal incentive for commercialization would exist. The effect would be similar to that if no patent were issued.[64] License policy or exclusive licenses, on the other hand, allow the contractor to retain the principal rights (while granting the government a license) and the traditional incentive of the monopoly grant remains in effect.[65]

Second, under present legal institutions, the government neither needs nor can use more than a royalty-free license to an invention. The government itself is not in the business of commercializing inventions. Such commercialization would have to be contracted out to private industry. License policy advocates maintain that the cost to the public of commercializing an invention by the latter means generally far exceeds the cost of allowing the original

contractor to hold the title. In the exceptional case where private risk capital is not available for commercializing an important invention, the government could induce the development of the invention through a publicly funded development contract.

Title policy advocates answer the first line of argument by noting that the cost-plus-fixed-fee research contracts eliminate the need of a monopoly grant to compensate for initial investment and R&D risks.[66] Additionally, high technology R&D contracts are generally let to the largest firms in high-concentration and high-barrier industries. These industries do not need the traditional incentive of a patent system to induce invention commercialization. Commercialization would follow simply from the government's granting a nonexclusive license in title policy.

New products constantly develop in fields with no patent protection. This seems the result primarily of the need to maintain the competitive stance with innovating competitors and to the natural advantage over competitors which the innovator wins. If there as a demand for a product, title policy advocates argue, the product will be commercialized, patent or no patent. Also, we empirically observe that businesses take nonexclusive licenses from TVA, HEW, and the Department of Agriculture. Examples of such licenses are frozen orange juice concentrates, aerosol bombs, oral polio vaccines, and many granular fertilizers.[67] However, Harbridge House found in a study of 2,024 contractor inventions, only 251 were used commercially. Of these, 200 were utilized by industrial contractors and 51 by licensees. Only 55 of the inventions played a critical role in the commercial products in which they were used. Defense contracts accounted for 198 of the inventions.[68] The Harbridge House study further concludes that once an invention is developed, the major factors influencing its actual commercialization are: (1) the extent of market demand for products employing the invention (if any); (2) the degree of promotion by

government agencies which sponsored the research; (3) the size of the firm's investment necessary to bring it to market; (4) the prior experience and attitude toward innovations of the organization that developed them; and (5) the type of patent rights available to protect the firm's investment.

Issue 6: Economic Concentration in Industry

License policy advocates maintain that title policy favors big business.[69] Title policies skew contracts to big business, since they can better afford the low profit margin and high risk of project termination.[70] This tends to limit entry of new firms. Larger firms also depend less than small firms on a subsequent supply contract for the production of the resultant product. The importance of this problem in the literature appears to have been treated solely as one of equity. Neither the degree of the favoritism nor its effects have been examined in detail by license policy advocates. In particular, the link between economic concentration and product commercialization potential is not examined.

License policy advocates maintain that economic concentration problems, if any, may be adequately handled by traditional antitrust proceedings.[71] They further claim that the position of the title policy advocates on this issue is therefore of little consequence. Nor does the absence of monopoly protection discourage entry of small firms. Large examples may be found in color film processing and the production of cards and equipment for computer cards.

The Atomic Energy Commission has always argued that title policy was necessary to prevent heavy concentration in the atomic energy field. Since much of the AEC's early programmatic R&D was conducted by a small number of contractors, it was feared that if the contractors were allowed rights, after a short period of time it would be impossible for a small firm to enter.

Another line of argument posed by some researchers is that the issue is mute, since the patents themselves have little or no commercial value. Support for their argument was first provided by an examination of patents owned by DOD contractors. Later a general examination concluded with similar results.[72] The Harbridge House study found that sales of inventions were heavily concentrated in a few patents. Over 88% of the contractor sales where the inventors played a critical role were attributable to five patents (out of 200 commercially utilized contractor inventions). It was also found to be the case that the value of licenses was concentrated in a few patents.[73]

IV CONCLUSION

Over the years, as this literature review shows, the advocates of one type of patent policy or another have all dealt with the kind of welfare questions raised, both in the opening of this paper and earlier, in the political arena, during World War II. All these questions -- the matter of equity, the effect on industrial concentration; the opportunities of small business; the commercialization of new products and processes; the pace of technological innovation -- remain live issues for federal patent policy. But the arguments advanced pro and contra title and license policy have not differed significantly from those advanced back in World War II. More important, the arguments seem to amount to little more than assertions whose thrust correlates highly with the economic or bureaucratic interests of the groups espousing them. Given this sort of analytical disagreement, one would not expect to find much uniformity in the practical license versus title policies of federal agencies. Indeed, for the three most important R&D agencies -- DOD, AEC and NASA -- the policy choices adopted in the postwar era have been as diverse as the choices available.

The Department of Defense retained a license policy approach. Despite contractor pressure, the Department refused to modify the existing policy of taking a license for all governmental, as opposed to only defense, purposes. For one thing, policy planners in the military

worried that if they agreed to let their contractors deny royalty-free licenses to other agencies of the government, those other agencies might do the same to the armed services. For another, military planners also believed that it was not, for example, the Navy Department which was funding R&D but the U.S. government, and accordingly, the government as a whole ought as a matter of equity to receive the appropriate royalty-free license. The Department did define three situations in which the government's taking title would be deemed appropriate, but in all of them the burden of proof rested on the government.[74]

The Atomic Energy Commission adopted a thoroughgoing title policy. Within the administration, some of the key framers of the atomic energy act of 1946 wholeheartedly agreed with the position of Kilgore and the Attorney General's report insofar as the ownership of patents was concerned. They considered it especially appropriate to adopt a title policy in the case of atomic energy. For one thing, the government had footed the vast majority of the cost to transform the scientific phenomenon of nuclear fission into a source of explosive power. For another, because nuclear energy seemed so special a case for postwar R&D policy, it seemed desirable that the government be responsible for the commercial as well as the military development in the field.

Patent policy figured prominently in the revision of the Atomic Energy Act in 1954. Under the terms of the statute, the AEC was given authority for a more flexible disposition of patents deriving from research which it sponsored. The contractor could obtain title under certain circumstances, e.g., if the patents were for devices not related to atomic energy and if the contractor already occupied an established position in the field. Moreover, the AEC was granted general authority to issue waivers of title. Waiver was normally exercised in the case of development contracts for devices or processes related to the production of fuel elements and fuel and core cartridge assemblies. However, in the case of all inventions directly related to atomic energy, the AEC took title and the contractor got nothing.[75]

NASA's patent policy fell between that of the AEC and DOD. When the National Aeronautics and Space Act was passed in 1958, a number of Congressmen feared that just a few inventions could place the fate of -- and the profits from -- the entire space effort in the hands of a few contractors. Accordingly, the act stipulated a title policy for NASA R&D contracts, especially if the inventions were pertinent to the development and operation of space vehicles or important to continued research in space flight. However, the NASA administrator was given the authority to waive title if he deemed such waiver in the public interest. The waiver was generally to be exercised in two situations: first, if private ownership seemed likely to result in the speediest practical exploitation of the invention; second, if the contractor had sufficiently substantial equities to justify the retention of rights.

At the outset, NASA claimed that contractors seemed reluctant to accept NASA contracts because of its strict title policy, and it was said that those who were retained did not put forth maximum efforts. Considering itself at a disadvantage compared with the Department of Defense, NASA administrators called for legislative relief in the direction of a license policy. Despite Congressional hearings into the issue, no modification of the law was passed. But what Congress refused to grant, NASA managed to obtain on its own hook. The agency administered the waiver regulation with considerable liberality, so much, in fact, that NASA contractors seemed generally pleased.[76]

No doubt in part because of the variations in patent practice, calls for some sort of uniform policy have continued. Both Presidents Kennedy and Nixon issued memoranda designed to create one; both seem so laced with hoopholes as to nullify the achievement of uniformity. Like the individual agency policies themselves, the transformation of the memoranda into practice seems to have been shaped mainly by the interaction of the particular bureaucracy with its client contractors. It has evidently not been shaped by rational and factual analysis of how different variations might affect the welfare output. The improvement

of federal patent policy -- in federal R&D contracts or otherwise -- thus seems to be freighted with considerable political difficulty.

But, as we hope this review makes clear, it is also burdened by inadequate understanding of what role the patent system plays in the encouragement of innovation, and also by inadequate assessments of the welfare effects of various manipulations of patent policy. As we have pointed out in Section III, the opportunities for such manipulations are diverse and numerous. They include adjustments in the specific property rights of the grant, in the nature of inventions required for the award of a patent, in the procurement of the grant, and in its enforcement. It would, however, be unwise to adopt any of these manipulations without first exploring their effects, in both legal and economic terms. Otherwise, there will be no more rational and theoretical foundation for a reformed federal patent policy than there has been for the policy in federal R&D contracts.

FOOTNOTES

1. Arnold Plant, "The Economic Theory Concerning Patents for Inventions," Economica N. S. 1 (February 1934), pp. 30-51 (hereafter cited as "Patents for Inventions"); and Fritz Machup, "An Economic Review of the Patent System," Study No. 15 of the Subcommittee on Patents, Trademarks and Copyrights of the Committee on the Judiciary, U. S. Senate, 85th Congress, 2nd Session (1958).

2. Plant, "Patents for Inventions," p. 39.

3. Plant, "Patents for Inventions," p. 39.

4. Plant, "Patents for Inventions," p. 51.

5. U. S. Senate, Investigation of Concentration of Economic Power: Final Report and Recommendations of the Temporary National Economic Committee, 77th Congress, 1st Session, Senate Document No. 35, 1941, pp. 36, 249, 269.

6. New York Times, March 26, 1942, pp. 1, 16.

7. Carroll W. Pursell, Jr., ed., The Military Industrial Complex (New York, 1972), pp. 165, 168-69.

8. Ward Bowman, Patent and Antitrust Law: A Legal and Economic Appraisal, (Chicago: University of Chicago Press, 1973).

9. For example, see R. C. Nordhaus, "Antitrust Laws and Public Policy in Relation to Patents," Duquesne University Law Review, Vol. 3, (Fall 1964), pp. 1-23; J. B. Gambrell, "Patents and Antitrusts: An Integrated Approach in the European Economic Community," Boston College Industrial and Commercial Law Review, Vol. 6, (Spring 1965), pp. 541-560; C. E. Mueller, "Antitrust and Economics: A Look at 'Competition,'" St. Louis University Law Journal, Vol. 10, (Summer 1966), pp. 482-516; J. B. Kennedy, Jr., "Patent and Antitrust Policy: The Search for a Unitary Theory," George Washington Law Review, Vol. 35, (March 1967), pp. 512-561; G. Kadish, "Patents and Antitrust: Guides and Caveats," Idea, Vol. 13, (Spring 1969), pp. 83-121; M. J. Adelman, R. P. Jaress, "Patent-Antitrust Law: A New Theory," Wayne Law Review Vol. 17 (January-February 1971), pp. 1-23; S. C. Oppenheim, "Patent-Antitrust Spectrum of Patent and Know-how License Limitations: Accommodation? Conflict? or Antitrust Supremacy?" Idea, Vol. 15 (Spring 1971),

pp. 1-25; and J A. Kidwell, "Patent-Right Interchange and Antitrust Policy: Defining the Interface," University of Colorado Law Review, Vol. 43, (June 1972), pp. 369-398. Also of interest may be several seminars and panels on patent-antitrust interaction. A sample of these seminars and panels include "Patent and Trade-Mark Aspects of the Report of the Attorney General's National Committee to Study the Antitrust Laws" -- a symposium. Antitrust Bulletin, Vol. 1 (June 1955), pp. 156-187; Symposium: "Patents, Know-how and Antitrust," University of Pittsburgh Law Review, Vol. 28 (December 1966), pp. 197-349; "Symposium on Patents and Antitrust Law," ABA Antitrust Law Journal, Vol. 39 (1970), pp. 777-832; and "Seminar on Patent-Antitrust Problems: A Panel," American Bar Association Antitrust Law Journal, Vol. 40 (1970-71), p. 158.

10. K. Arrow, "Economic Welfare and the Allocation of Resources to Invention," Essays in Theory of Risk Bearing (Chicago: Markham, 1971), pp. 144-164 (hereafter cited as "Economic Welfare").

11. J. Hirschleifer, "The Private and Social Value of Information and the Reward to Inventive Activity," American Economic Review, Vol. 61 (1971) (hereafter cited as "Reward to Inventive Activity").

12. E. Mansfield, "The Speed of Response of Firms to New Techniques," Quarterly Journal of Economics (May 1963), pp. 290-309.

13. M. Kamien and N. Schwartz, "Timing of Innovations Under Rivalry," Econometrica (January 1972), pp. 43-60.

14. Y. Barzel, "Optimal Timing of Innovations," Review of Economics and Statistics (August 1968), pp. 348-355.

15. F. M. Scherer, "Research and Development Allocation Under Rivalry," Quarterly Journal of Economics (August 1967), pp. 359-394.

16. Scherer, "Research and Development Allocation Under Rivalry," p. 390.

17. J. McGee, "Patent Exploitation: Some Economic and Legal Problems," Journal of Law and Economics (1966), pp. 135-162.

18. M. Kamien and N. Schwartz, "Patent Life and R&D Rivalry," American Economic Review, Vol. 64 (1) (March 1974), pp. 183-187.

19. For an in depth analysis of the rights of research personnel and their employers, see Frederick Neumeyer, The Employed Inventor in the United States: Policies, Law, and Practice (Cambridge, Mass.: M.I.T. Press, 1971). See also, "Validity and Enforceability of Restrictive Covenants in Contracts of Employment," American Law Reports, Vol. 9 (1920), pp. 1407-1468; Ambrose Doskow, ed., "Notes," "Rights of Employers in Inventions of Employees," Columbia Law Review, Vol. 30 (1930), pp. 1172, 1176-1177; K. O'Connor, "Patent Policies for Employees," Management Record (August 1952); Arthur Bishop, Jr., "Employers, Employees, and Inventions," Southern California Law Review, Vol. 31 (1957), pp. 52-54; Wilson Maltby, "A Government Patent Policy for Employees Inventions," Federal Bar Journal, Vol. 21 (1961), pp. 127-145; J. Rossman, "Rewards and Incentives to Employee-Inventors," Idea Vol. 7 (1964), pp. 431-460; T. Lassagne, "The Legal Rights of Employed Inventors," American Bar Association Journal, Vol. 51 (1965), pp. 835-840; W. Maltby, "Need for a Federal Policy to Foster Invention Disclosures by Contractors and Employees," Federal Bar Journal, Vol. 25 (1965), pp. 32-40; I. Louis Wolk, "An Attorney's View of the Employee Inventor," Journal of the Patent Office Society, Vol. 47 (1965), pp. 483, 487; Ephraim K. Cohen, "Rights of Employer and Employee in Patentable Inventions," American Patent Law Association Bulletin (April-May 1966), pp. 193-196; John W. Leonard, "The Protected Rights of the Employee Inventor in his Invention," Journal of the Patent Office Society, Vol. 49 (1967), pp. 357-371; and John Stedman, "The Employed Inventor, the Public Interest, and Horse and Buggy Law in the Space Age," New York University Law Review, Vol. 45 (March 1970), pp. 1-32.

20. Arrow, "Economic Welfare," and Hirschleiffer, "Reward to Inventive Activity."

21. Nordhaus's book seems to be one of the few studies to examine this phenomenon in much detail. Invention, Growth and Welfare (Cambridge, Mass.: 1969).

22. Arrow, "Economic Welfare,"

23. Kitch, Graham v. John Deere Co.: New Standards for Patents, 1966 Supreme Court Review 293, pp. 330-35.

24. More recently, see Justice Abe Fortas's opinion in Brenner v. Manson, 383 U. S. 519 (1966).

25. Arrow, "Economic Welfare."

26. At present, a great deal of controversy exists on the effects of various definitions of patentability on the development of computer software. For example, see A. H. Seidel, "Computers: Antitrust, Patent, and Copyright Law Implications," Antitrust Bulletin, Vol. 6 (1961), pp. 549-559; "Patentability of Computer Programs," New York University Law Review Vol. 38 (November 1963), pp. 891-917; M C. Jacobs, "Patent Protection of Computer Programs," Journal of the Patent Office Society, Vol. 47 (January 1965), pp. 6-14; John Banzhaf, "Copyright Protection for Computer Programs," ASCAP Copyright Law Symposium, No. 14 (1966); David Bender, "Computer Programs: Should They be Patentable?" Colorado Law Review Vol. 68 (1968), pp. 466-496; Ronald V. Thurman, "Adequate Legal Protection for Computer Programs," Utah Law Review, (1968), pp. 369-394; H. R. Koller and J. Mashman, "Patent Protection for Computer Software: Implications for the Industry," Idea Vol. 12, (Winter 1968-69), pp. 1109-1127; R. O. Nimitz, "Patentability of Computer Programs," Rutgers Journal of Computers and Law (Spring 1970), pp. 38-44; V. E. Woodcock, "Mental Steps and Computer Programs," Journal of Patent Office Society, Vol. 52 (May 1970), pp. 275-292; "Software Protection: Patents, Copyright, and Trade Secrets," Albany Law Review Vol. 35 (1971), pp. 695-717; and the symposium on Infosystems in Jurimetrics, Vol. 13 (Spring 1973).

27. A. Phillips, "Patents, Potential Competition, and Technical Progress," in Papers and Proceedings of the American Economic Association (1966), p. 309.

28. See Scherer, "Research and Development Allocation Under Rivalry."

29. W. Baldwin and G. Childs, "The Fast Second in Research and Development," Southern Economic Journal (July 1969), pp. 18-24.

30. W. Comanor, "Research and Competitive Product Differentiation in the Pharmaceutical Industry in the United States," Economica (1964) p. 369.

31. J. Ferejohn and D. Grether, "On the Introduction of a Patent System," Caltech Social Science Working Paper No. 32.

32. Hirschleifer, "Reward to Inventive Activity."

33. Hirschliefer, "Reward to Inventive Activity."

34. It may be possible by statue for a government contractor to openly infringe a domestic patent with complete immunity to an extent authorized or consented to by the government. See John TeSelle, "Authorization of Consent to Infringe Patents in Production for the Government," George Washington University Law Review, Vol. 26 (1947), pp. 583-611.

35. The full text of Kilgore's bill is in Science, 97 (May 7, 1943), pp. 401-412.

36. For typical expressions of opposition, see U. S. Senate, Subcommittee of the Committee on Military Affairs, Hearings, Technological Mobilization, 77th Congress, 2nd Session, 1942, pp. 240-41, 245, 271; Walter S. Landis (Vice President of American Cyanamid Co.), What's Wrong with the Kilgore Bill (privately printed, October 1943); Legislation . . . That Could Radically Change Our Whole Economic Structure (Commerce and Industry Association of New York, November 1943); L. Q. Hawkins, "Regimentation of Science," Electrical World, June 26, 1943; Julius A Furer, "Memo for Files," March 26, 1943 and Ralph Bard to Chairman, Senate Committee on Military Affairs, June 2, 1943, Records of the Naval Coordinator of Research and Development, in Records of the Office of Naval Research, RG298, Federal Records Center, Suitland, Maryland, Kilgore bill file; Harvey H. Bundy to Colonel Ege, April 3, 1943, and attached documents, Records of the Office of the Secretary of War, RG107, National Archives, Washington, D. C., Entry 82, Box 73, Technological Mobilization bill.

37. Report of the National Patent Planning Commission, June 18, 1943, H. Doc. 239, 78th Congress, 1st Session; Second Report of the National Patent Planning Commission, January 9, 1945, H. Doc. 22, 79th Congress, 1st Session; Third Report of the National Patent Planning Commission, September 6, 1945, H. Doc. 283, 79th Congress, 1st Session.

38. Second Report of the National Patent Planning Commission, p. 5.

39. U. S. Department of Justice, Investigation of Government Patent Practices and Policies: Report and Recommendations of the Attorney General to the President (3 vols.; Washington, D. C.: Government Printing Office, 1947).

40. Tom Clark, "Memorandum for the President," October 21, 1946, Harry S. Truman Papers, Harry S. Truman Library, Independence, Mo., (hereafter cited as "Truman Papers") OF 416-A.

41. Kenneth C. Royall to the President, January 27, 1947, "Truman Papers," OF 416-A.

42. Forrestal to the President, January 29, 1947, "Truman Papers," OF 416-A.

43. Krug to the President, February 4, 1947; Secretary of Commerce to the President, February 11, 1947; Kilgore to Clark C. Clifford, October 23, 1946; Kingsley to John R. Steelman, April 1, 1947, "Truman Papers," OF 416-A.

44. Frank J. Wille, "Government Ownership of Patents," Fordham Law Review Vol. 12 (May 1943), pp. 105-129.

45. Charles L. Shelton, "Government Patent Policy," Journal of Air Law and Commerce Vol. 33 (1967), pp. 39-61.

46. John Boyle, "Exploitation of Government-Owned Patents," Journal of the Patent Office Society Vol. 35 (3) (1953), pp. 188-213; and "Patent Practices of the FAA," report of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, United States Senate, 86th Congress, 2nd Session (1961), pp. 10-11.

47. United States Department of Justice, "Investigation of Government Patent Practices and Policies," Report and Recommendations of the Attorney General to the President Vol. 1 (Washington, D. C.: Government Printing Office, 1947) (hereafter cited as "Patent Investigation").

48. Boyle, "Exploitation of Government-Owned Patents"; United States Department of Justice, "Patent Investigation"; Elliot Gerber, "Patents -- Inventions by Federal Employees and Contractors -- Disposition of Title and Rewards," Journal of the Patent Office Society Vol. 35 (6), pp. 426-441 (hereafter cited as "Patents -- Inventions"); "Patents, Trademarks, and Copyrights," Report of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, United States Senate 89th Congress, 2nd Session, (1966); Patent Policies of Government Departments and Agencies, 1960, Conference on Federal Patent Policies, Senator Russell B. Long and Vice Admiral H. G. Rickover, United States Navy

(hereafter cited as Patent Policies); Committee Print of the Subcommittee of the Senate Select Committee on Small Business, 86th Congress, 1st Session (1960); Hearings on the Effect of Patent Policies on Competition, Monopoly, Economic Growth and Small Business before a Subcommittee of the Senate Select Committee on Small Business, 86th Congress, 1st Session (December 8, 9, 10, 1959), testimony of Senator Russell B. Long, especially pp. 115-319; Hearings on S. 789, S. 1809 and S. 1899 before the Subcommittee on Patents, Trademarks and Copyrights of the Committee on the Judiciary, United States Senate, 89th Congress, 1st Session, testimony of Russell B. Long, Part I, p. 336; "Patent Practices of the Department of Defense," Preliminary Report Pursuant to S. Res. No. 55, Committee on the Judiciary, United States Senate, 87th Congress, 1st Session (1961); Donald S. Watson, Harold F. Bright and Arthur E. Burne, "Research Project Report, Federal Patent Policies in Contracts for Research and Development," Patent, Trademark and Copyright Journal of Research and Education (414), pp. 109-130, 273-296 (hereafter cited as "Research Project Report").

49. Arthur J. Keeffe and David M. Lewis, Jr., "The Department of Defense Patent Policy at the Crossroads: An Argument for the Retention of Traditional Incentives," Catholic University Law Review Vol. 10 (1) (1961), pp. 22-23 (hereafter cited as "Traditional Incentives").

50. Gerber, "Patents -- Inventions"; Keeffe and Lewis, "Traditional Incentives"; Emilio Q. Daddario, "Effects of Government Patent Policy on Research and Development," Journal of the Patent Office Society Vol. 45 (10) (October 1963), pp. 663-672 (hereafter cited as "Effects . . . on R&D"); and Helge Holst, "Government Patent Policy -- Its impact on Contractor Cooperation with the Government and Widespread Use of Government Sponsored Technology," Patent Trademark and Copyright Journal of Research and Education Vol. 9 (1965), pp. 109-130, 273-296.

51. Watson, Bright and Burns, "Research Project Report"; Reed C. Lawler, "The Public Interest in Non-Governmental Ownership in Patents," Journal of the Patent Office Society Vol. 43 (7) (July 1961), pp. 447-466; "Proposed Revision to the Patent Section, National Aeronautics and Space Act of 1958," Report of the Subcommittee on Patents and Scientific Inventions of the Committee on Science and Astronautics, United States House

of Representatives, 86th Congress, (1960), (hereafter cited as "Proposed Revision"); Hearings on P. L. 85-568 before the Subcommittee on Patents and Scientific Inventions of the Committee on Science and Astronautics, United States House of Representatives, 86th Congress, 1st Session (August 19, 20, November 30, December 1-5, 1959), pp. 398-399, 412.

52. Patent Policies; and Hearings on National Patent Policy before the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, United States Senate, 87th Congress, 1st Session (1961), pp. 2-3.

53. Elmer J. Gorn, "Toward a Sound National Policy for Disposition of Patent Rights under Government Contract," in Symposium on Government Contract Patent Policy, Federal Bar Journal Vol. 21 (1) (Winter 1961), pp. 105-120 (hereafter cited as "Sound National Policy"); and Russell B. Long, "Federal Contract Patent Policy and the Public Interest," in Symposium on Government Contract Patent Policy, Federal Bar Journal Vol. 21 (1) (Winter 1961), pp. 7-25 (hereafter cited as "Federal Contract").

54. Gorn, "Sound National Policy."

55. Patent Policies.

56. Shelton, "Government Patent Policy"; Gorn, "Sound National Policy"; Mary A. Holman, "The Utilization of Government-Owned Patented Inventions," Patent, Trademark and Copyright Journal of Research and Education Vol. 7 (1963), pp. 109-161, 321-375; and Hearings on P. L. 85-568 before the Subcommittee on Patents and Scientific Inventions of the Committee on Science and Astronautics, United States House of Representative, 86th Congress, 1st Session (August 19, 20, November 30, December 1-5 1959), testimony of Mr. J. King Harness, pp. 419-421.

57. Roland A. Anderson, "If There is an Invention Under a Government Contract - Who Should Get It?" in Symposium on Government Contract Policy, Federal Bar Journal Vol. 21 (1) (Winter 1961), p. 70.

58. "Patents, Trademarks, and Copyrights."

59. Samuel I. Doctors, "Transfer of Space Technology to the American Consumer: The Effect of NASA"S Patent Policy," Minnesota Law Review Vol. 52 (4) (March 1968), pp. 789-818.

60. Daddario, "Effects . . . on R&D."

61. Overton Brooks, "Ownership and Use of Space are Ideas - A Legislative Approach," in Symposium on Government Contract Patent Policy, Federal Bar Journal Vol. 21 (1) (Winter 1961), pp. 26-36.

62. Holman, "Patented Inventions."

63. Lawler, "The Public Interest."

64. Wille, "Government Ownership of Patents"; and United States Department of Justice, Investigation of Government Patent Practices and Policies, Report and Recommendations of the Attorney General to the President Vol. III (Washington, D. C.: Government Printing Office, 1947), testimony of Vannevar Bush (pp. 260-262) and P. V. Cardon (pp. 261-262).

65. Proposed Revision; Robert L. Birch, "The Creative Incentive: The Patent System and the Incubation of Industrial Hardware," Journal of the Patent Office Society Vol. 48 (11) (November 1966), pp. 689-695; Albert J. Kramer, "Exclusive Licenses Under Government-Owned Patents," Journal of the Patent Office Society Vol. 28 (5) (May 1946), pp. 319-324; and Second Report, National Patent Planning Commission, 1944.

66. Patent Policies; and Long, "Federal Contract."

67. Keeffe and Lewis, "Traditional Incentives"; and Hearings on S. 3156 before the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, United States Senate, 86th Congress, 2nd Session (1960).

68. Harbridge House, Inc., Government Patent Policy Study, Final Report, Volume I, prepared for the Federal Council on Science and Technology (1968).

69. David Lloyd Kreeger, "The Control of Patent Rights Resulting from Federal Research," Law and Contemporary Problems Vol. 12 (1947), pp. 714-745.

70. Proposed Revision.

71. Keeffe and Lewis, "Traditional Incentives"; Daddario. "Effects . . . on R&D"; and Neil B. Siegel, "Patent Monopoly and Sherman Act Monopolization," Journal of the Patent Office Society Vol. 49 (2) (February 1967), pp. 67-80.

72. Holman, "Patented Inventions."

73. Harbridge House, Inc., Government Patent Policy Study.

74. James A. Dobkin, "Patent Policy in Government Research and Development Contracts," Virginia Law Review 53 (1967), pp. 586-91 (hereafter cited as "Patent Policy").

75. Dobkin, "Patent Policy," pp. 570-74.

76. Dobkin, "Patent Policy," pp. 574-80.